Laser Welds for AMS 02 TTCS Evaporator

Base material: 316L

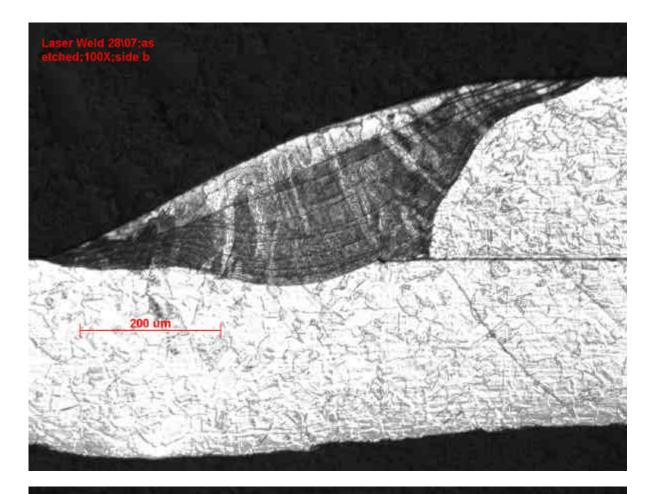
Specimen Traceability Numbers: ASM006\04\04\28\7,

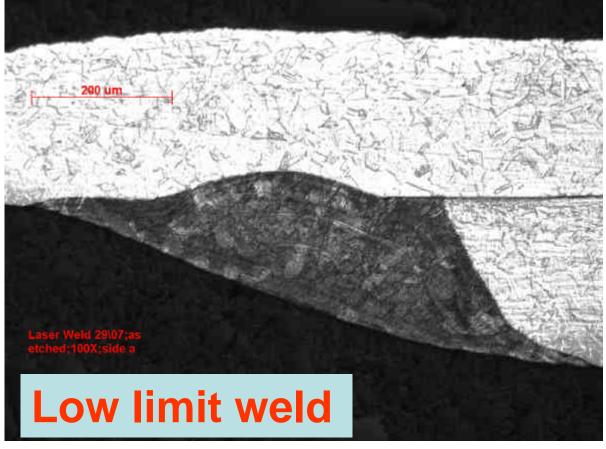
ASM006\04\04\28\4, ASM006\04\04\28\1

Three cross-sections were taken transverse to the laser weld, mounted, ground and polished. Then, the six weld locations on the cross-sections were electrolytically etched with 10% oxalic acid and examined on the metallograph.

The laser welds were judged to be sound and of high quality. No metallurgical anomalies were detected at magnifications up to and including 1000X. There was no notches, no lapped material, no pores, no voids, and no cracks detected. Penetration and fusion were proper for this type of socket weld.

John Figert
Metallurgical Engineer, P.E.
Lockheed Martin Space Operations





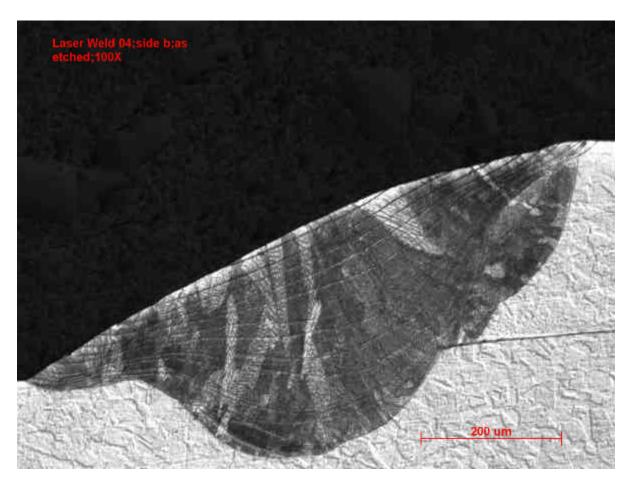
Low limit Welding Procedure Specification

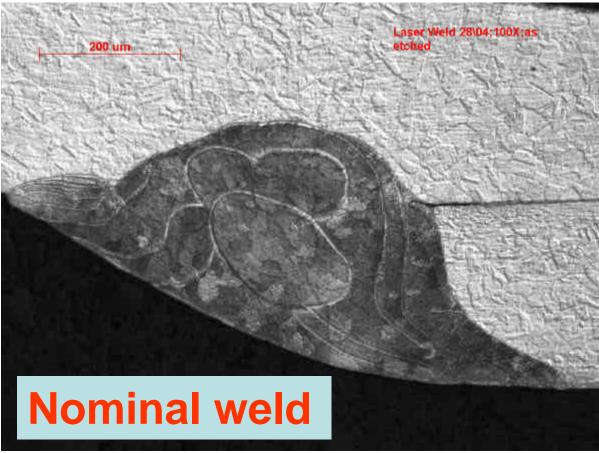


SHELL CHEMICALS, SRTCA

LASER WELDING PROCEDURE SPECIFICATION (WPS)

WPS Number ASM006\Qu\ou\t3\ 7 Revisio	Company / Organization TIC/AEI4
	Welding Process(es) LASER WELDING
BASE and FILLER METAL: Material number45376823600	to Material number <u>45375832763</u> 3 <u>X 0.2 MM</u> to Material spec., type, & grade 14404 DIN17458 D4/T3
Base metal thickness range	- GAS:
Pipe / Tube diameter 4,00 Wall thickness 0.7	Torch/Head gas(es) ARGON 4.6
Filler metal F No. X AWS Class & Spec.	— % Composition 4.6 Flow Rate 6,LPM
Consumable Insert, AWS Class & Spec	Prepurge Time 40 SEC Postpurge Time 15 SEC
	Backing gas(es) ARGON 4.6
WELDING SET-UP:	% Composition 4.6 Flow rate
Power Supply (Model) HAAS LASER NEODYLIM YAG P54	Prepurge Time 40 SEC Postpurge Time 15 SEC
Weld Head(s)	
Joint Position(s)	PRE and POSTWELD HEAT
Tungsten type Diameter Arc gap	
Tip diemeter Tip angle	Preheat temperature minimum
Weld direction ROTATION VERT Pulse Mode_	Preheat temperatue maximum
	Interpass temperature minimum
	Interpass temperature maximum Postweld HeatTreatment
WELD SETTINGS:	Postwerd Fleath (earlier)
KW POWER 1,4	
DURATION (MS) 2,8	- JOINT DESIGN
PULSE ENERGY 3.4 \	- Joint type
PULSE REPETITION FREQUENTCY DOWNSLOPE 10 SEC	Groove angle Radius Land
FIXTURE SPEED OS RPM	- Root opening Size of fillet
E 9,75.	Socket weld pull-back
NOMINAL HEAT INPUT CONDITIONS:	SETUP SKETCH -
Weld Allowable Current (amps) Settings Pulse Puls Level Time HIGH LOW Rate Wid Number (sec.) +5% Nominal -5% Nominal (pps) Nominal	₩1
$\frac{2}{3}$ $\frac{1}{4}$ $\frac{1}$	- 1 _{3H}
TECHNIQUE: Joint deaning etanol Other	
We certify that this welding procedure and schedule were qualified in	accordance with the requirements of NASA / JSC PRC-0010.
Prepared By M.W. Gussekloo o	rg Date
	2.300 A
Approved	rg Date





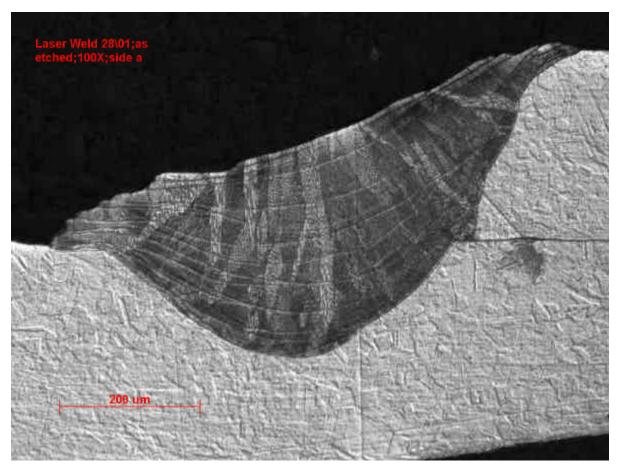
Nominal Welding Procedure Specification

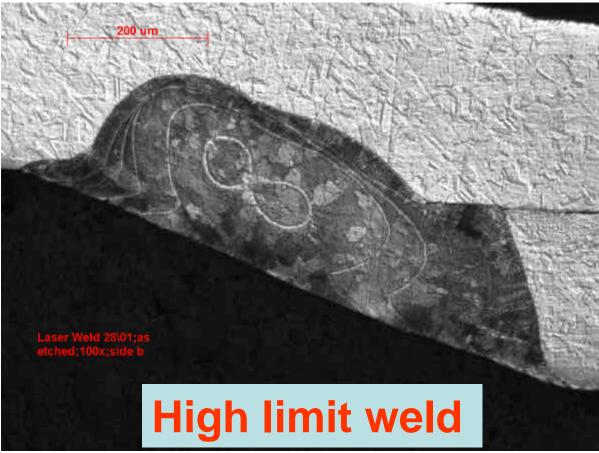


SHELL CHEMICALS, SRTCA

LASER WELDING PROCEDURE SPECIFICATION (WPS)

WPS Number ASM008/04/04/28/LI Revisio	Company / Organization TIC/AEI4	
	Welding Process(es) LASER WELDING	
BASE and FILLER METAL : Material number 45376823600 Group	to Material number <u>45376832763</u> 3X 0.2 MM to Material spec., type, & grade 14404 DIN17458 D4/T3	
Material spec., type, and grade 14404 DIN17458 D4/T3		
Base metal thickness range Pipe / Tube diameter 4,00 Wall thickness 0.7	— GAS:	
Filler metal F No. X AWS Class & Spec.	— Torch/Head gas(es) ARGON 4.6	
The state of the s	- % Composition 4.6 Flow Flate 6,LPM	
Consumable Insert, AWS Class & Spec	Prepurge Time 40 SEC Postpurge Time 15 SEC	
WW	Backing gas(es) ARGON 4.6	
WELDING SET-UP :	% Composition 4.6 Flow rate	
Power Supply (Model) HAAS LASER NEODYUM YAG P54 Weld Head(s)	Prepurge Time 40 SEC Postpurge Time 16 SEC	
Joint Position(s)	PRE and POSTWELD HEAT	
Tungsten type Diameter Arc gap	Preheat temperature minimum	
Tip diameter Tip angle Weld direction ROTATION VERT Pulse Mode	Preheat temperatue maximum	
Weld direction ROTATION VERT Pulse Mode	Interpass temperature minimum	
	Interpass temperature maximum	
	Postweld HeatTreatment	
WELD SETTINGS:	7.3011137.7.100.7.10137.11	
KW POWER 1,0		
DURATION (MS) 2,8	- JOINT DESIGN	
PULSE ENERGY 4,6	- Joint type	
PULSE REPETITION FREQUENTCY 6 DOWNSLOPE 10 SEC	Groove angle Radius Land Land	
FIXTURE SPEED OC. RPM	- Root opening Size of fillet	
F 4.35	Socket weld pull-back	
	THE PART OF THE PA	
NOMINAL HEAT INPUT CONDITIONS:	SETUP SKETCH -	
Weld Allowable Current (amps) Settings Pulse Pulse Level Time HIGH LOW Rate Wid Number (sec.) +5% Nominal -5% Nominal (pps) Nomi	th	
2 3 4		
TECHNIQUE:		
Joint cleaning etanol Other		
We certify that this welding procedure and schedule were qualified in	n accordance with the requirements of NASA / JSC PRC-0010.	
Prepared By H W. Gussek Loo 0	rg Date	
	ra -	
Approved	Date	





High limit Welding Procedure Specification



SHELL CHEMICALS, SRTCA

LASER WELDING PROCEDURE SPECIFICATION (WPS)

WPS Number ASM006/9 4 \0 4\28 Revisio	ompany / OrganizationTiC/AEI4	
	Welding Process(es) LASER WELDING	
BASE and FILLER METAL :		
Material number _45376823600 Group	to Meterial number 45378832763 3X.0.2 MM	
Material spec., type, and grade 14404 DIN17458 D4/T3	to Meterial specifying & grade 14404 DIN17459 D4773	
Base metal thickness range	GAS:	
Pips / Tube diameter 4,00 Wall thickness 0.7		
Filler metal F.No. X AWS Class & Spec.	% Composition 4.8 Flow Plate 6,LPM	
Consumable Insert, AWS Class & Spec	Prepurge Time 40 SEC Postpurge Time 15 SEC	
Conce-in their solver of se	Backing gas(es) ARGON 4.8	
WELDING SET-UP:	% Composition 4.6 Flow rate	
Power Supply (Model) HAAS LASER NEODYUM YAG P54	Prepurge Time 40 SEC Postpurge Time 15 SEC	
Weld Head(s)		
Joint Position(s)		
Tungsten type Diameter Arc gi	PRE and POSTWELD HEAT	
Tip diameter Tip angle	Preheat temperature minimum	
Weld direction ROTATION VERT Pulse Mode	Preheat temperatue maximum	
	Interpass temperature minimum	
	Interpasa temperature maximum	
WELD SETTINGS :	Postweld HeatTreatment	
KW POWER 1. S		
DURATION (MS) 2 8		
PULSE ENERGY 5.\	JOINT DESIGN	
PULSE REPETITION FREQUENTCYL DOWNSLOPE 10:	SEC Joint type	
	Groove angle Hadius [2810	
FIXTURE SPEED OS APM	Root opening Size of fillet	
	Socket weld pull-back	
NOMINAL HEAT INPUT CONDITIONS:	SETUP SKETCH -	
	Pulse	
	Width	
Number (sec.) +5% Nominal -5% Nominal (pps) N	ominal of 3H7 (
24%	<u> </u>	
2		
3		
4		
	# 10	
TECHNIQUE:		
Joint disaning etanol Other		
-	_	
We cartify that this welding procedure and schedule were qualified	ed in accordance with the requirements of NASA / JSC PRC-0010.	
Prepared By	Org. Date	
1.10000		
Approved	Org Date	